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Invited Perspective: Prenatal $PM_{2.5}$ Exposure Associated with Adverse Birth Outcomes Requiring Medical Interventions

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Air pollution is a threat to human health, especially for vulnerable populations, with effects that span the life course. In particular, accumulating evidence links air pollution exposure during pregnancy with adverse birth outcomes, such as low birth weight and preterm birth.[1,2] These conditions put children at higher risk for illness in infancy and a range of health conditions into adulthood, including intellectual and developmental disabilities, obesity, diabetes, and heart disease.[3–5] Pollutant exposures during pregnancy are also associated with adverse respiratory outcomes in childhood, such as asthma.[6,7]

In this issue of *Environmental Health Perspectives*, Johnson et al. report results from their study of respiratory distress in a sample of >1,000 mother–child dyads across 10 Canadian cities, using air pollution exposures estimated from ground-level monitoring, satellite models, and land-use regression.[8] They did not observe associations between air pollution and mild signs of birth distress, but they did find associations with severe newborn respiratory distress. Specifically, higher exposure to fine particulate matter [PM ≤2.5 μm in aerodynamic diameter ($PM_{2.5}$)] was associated with increased risk of the need for assisted ventilation, administration of systemic antibiotics, and use of multiple clinical interventions for respiratory distress.

This work provides a novel contribution to the growing epidemiologic evidence for the adverse effects of prenatal exposures to $PM_{2.5}$, given that few studies have examined this outcome previously despite respiratory distress being a leading cause of neonatal morbidity and mortality worldwide.[9–11] These outcomes reflect critical neonatal conditions that are only partially explained by known risk factors, but little attention has been paid to environmental etiologic agents.

Common risk factors for severe respiratory distress include birth trauma, infection, and preterm birth (the newborn population in the new study was restricted to term births).[12] Birth trauma usually leads to low Apgar scores immediately after birth, but Johnson et al. did not observe associations between higher air pollution exposure and low Apgar scores at 1 min after birth. Mechanisms for the harmful health effects of air pollution include inflammation, oxidative stress, and epigenetic programming, leading to disruptions in fetal development and immune dysregulation.[6] Both epidemiologic and animal studies have identified alterations in immune system markers with higher prenatal air pollutant exposures.[13,14] The findings from the study by Johnson et al. further suggest that maternal $PM_{2.5}$ exposure could increase the potential for bacterial infection in newborns requiring treatment with antibiotics. This could also be explained by preemptive treatment for infection by physicians when an infant has respiratory distress.

Normal development and function of the maternal–fetal–placental unit is critical for normal fetal growth and birth. Johnson et al. also investigated several maternal factors, including prepregnancy metabolic disorders and hospitalization during pregnancy, finding that underlying maternal conditions, as well as maternal health during pregnancy, may amplify the adverse effect of $PM_{2.5}$ exposure on newborn health outcomes. Although additional work is needed to confirm these findings in studies with large sample sizes, these data suggest that clinicians should be aware that environmental factors may have significant impacts on newborn outcomes, requiring medical interventions.

This study contributes to the growing literature on prenatal exposure to $PM_{2.5}$ and child health, with implications for both policy and practice. Associations were observed in this study at pollutant levels—median $PM_{2.5}$ concentration of 8.9 $\mu g/m^3$ for the full pregnancy window—generally below the current regulatory level for annual mean $PM_{2.5}$ in the United States of 12 $\mu g/m^3$ (https://www.epa.gov/criteria-air-pollutants/naaqs-table). Consideration of groups sensitive to the effects of $PM_{2.5}$ (e.g., pregnant women, fetuses, children) in studies such as this one provide evidence to support strengthening the regulatory standard to protect these groups.[15] Air pollution may be contributing to the burden of neonatal respiratory stress, including in places with ambient $PM_{2.5}$ concentrations much higher than those reported in this study. Risks for adverse birth outcomes may be compounded for those who both live in high-exposure areas and do not have access to adequate hospital care during delivery, exacerbating perinatal health disparities. The results build on prior studies that, in totality, point to the need to educate policymakers, clinicians, and pregnant women regarding the effects of environmental risk factors, including $PM_{2.5}$ exposure, on birth and neonatal health.

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